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BY

RICHARD L. ROSENTHAL

U.S. ARMY ENGINEER TOPOGRAPHIC LABORATORIES

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The development of raster processing programs at USAETL has included programs for the generation of raster plot data containing cartographically symbolized features as well as the more widely investigated raster-to-vector software. Raster plot data may be used to generate film negatives with open window areas over which mechanical screens can be placed by conventional contact printing techniques. These areas can also be filled with digitally generated screens, a capability unique with the raster approach. Further, since most available raster plotting hardware does not permit the modulation of each pixel for intensity, it is desirable to

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) control groups of pixels in order to approximate a halftone dot for color or density control. A study was made to determine the suitability of the 25 micron pixel raster on the Digital Laser Platemaker for the generation of digital screens for absolute color and process color printing. Tests will be conducted to establish screen pattern and angle criteria to achieve desired results without moire. An associated literature search resulted in a fairly comprehensive bibliography of work published in the digital screening field.

DIGITAL SCREENING AND HALFTONE TECHNIQUES FOR RASTER PROCESSING

Richard L. Rosenthal
Cartographer
Automated Cartography Branch
US Army Engineer Topographic Laboratories
Fort Belvoir, VA 22060

BIOGRAPHICAL SKETCH

Richard Rosenthal is a cartographer specializing in automated and computerized techniques. He received his BA in Geography in 1976 from Boston University and is a candidate to receive a Master's in Cartography from the University of Wisconsin-Madison. He is currently employed in the Automated Cartography Branch of the US Army Engineer Topographic Laboratories. Research interests center on automated techniques for cartographic image display which include digital halftoning. Mr. Rosenthal is a member of ACSM.

ABSTRACT

The development of raster processing programs at USAETL has included programs for the generation of raster plot data containing cartographically symbolized features as well as the more widely investigated raster-to-vector software. Raster plot data may be used to generate film negatives with open window areas over which mechanical screens can be placed by conventional contact printing techniques. These areas can also be filled with digitally generated screens, a capability unique with the raster approach. Further, since most available raster plotting hardware does not permit the modulation of each pixel for intensity, it is desirable to control groups of pixels in order to approximate a halftone dot for color or density control. A study was made to determine the suitability of the 25 micron pixel raster on the Digital Laser Platemaker for the generation of digital screens for absolute color and process color printing. Tests will be conducted to establish screen pattern and angle criteria to achieve desired results without moire. An associated literature search resulted in a fairly comprehensive bibliography of work published in the digital screening field.

HISTORY

Research work in raster processing at the US Army Engineer Topographic Laboratories (USAETL) includes development of hardware and software. In-house hardware currently consists of a high-resolution IBM drum raster scanner/plotter. Raster processing software includes programs for raster-to-vector conversion (Staran Raster Processing Software, STRAPS), and contour tagging and elevation gridding (CONTAGRID). Software for identification of raster scanned cartographically symbolized features is under development.

Work is nearing completion for the development of hardware to plot raster information directly onto a printing plate. The Digital Laser Platemaker (LPM) is designed to accept printing plates up to 48 by 60 inches. The image (maximum size 42 by 59 inches) will be formed with a binary modulated, fixed size, 25 micron spot.

Creating a printing plate directly from digital data using the LPM will result in considerable savings of time and money. Many intermediate photomechanical steps currently employed in automated production will be eliminated and a significant reduction in materials will be realized by decreasing the use of lithographic film. Raster images suitable for map production will be compiled digitally from geographic data bases and plotted on the LPM. Using digital techniques, customized printed graphics will be available quickly and efficiently.

BACKGROUND

The Digital Laser Platemaker is designed to provide a capability for high-quality printing of raster data. Successful implementation and incorporation in automated production demands that the hardware be capable of plotting cartographically symbolized features at sufficient resolution for quality line-work. In addition, the LPM must plot raster representations of halftone and tint screens as area fill patterns, whether for single color or process color applications.

Currently, techniques for incorporating halftone and tint screens primarily use a combination of digital and photomechanical methods. Areas to be tinted are defined by a mask derived from the raster plotting of digital information. The raster image takes the form of a line image, when used to create a strip mask, or an open-window mask when synthesized directly at plot time. Standard photomechanical halftone and tint screens are used in conjunction with the digitally prepared masks in exposing a printing plate. It is possible to eliminate the need for this photomechanical screening if computer software is used to generate raster representations of halftone and tint screens. An area to be tinted, as defined by a digital data base, would incorporate a synthesized raster screen. Software creates a raster plot representation of a halftone screen. A requirement associated with raster plotted screens, as with photomechanical screens, is that they must provide gray-scale information for cartographic halftoning and tinting and be free from defects associated with halftoning of source images and multiple screen printing. The digital approach to halftoning presents the problem of finding a suitable method which considers the binary nature and constant size of the imaging dots.

PHOTOMECHANICAL HALFTONING

To assist in understanding the digital halftoning problem, a review of photomechanical halftoning might be helpful.

The most common printing techniques deposit ink on paper in a binary fashion. Two absolute output values are obtainable: the value of the paper and the value of the ink. The solution for producing a photographic range of density values on a binary system of ink and paper is based on Stephen Hargon's development of halftone printing. Hargon varied the diameter of an ink dot in proportion to its corresponding image intensity. Although each dot is printed at the full density of the printing ink, dot size variation produces an apparent gray scale. Resultant gray scale is dependent on screen type, camera optics, speed and contrast of photographic material, exposure, paperstock, and ink (Lasday 1972).

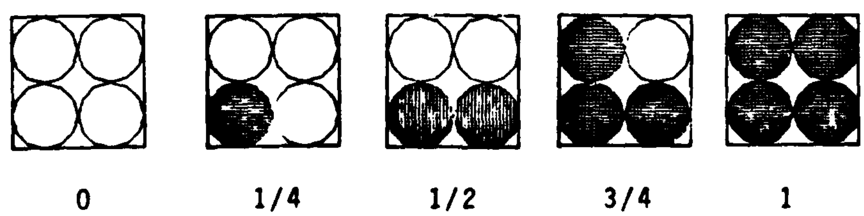
Gray-scale errors result from variation in printed dot size due to ink spread. Such errors are minimized by reducing the number of edges where spread may occur. This is achieved by limiting the screen frequency (Roetling 1977). When this limit is too great, patterns formed by the screen structure become apparent. Low-frequency patterns or moire are introduced when repetitive structures in the source image interact with the halftone screen. In cartographic applications, moire patterns commonly result from the interaction of two or more constant tone screens. Screen rotation is the accepted method for reducing moire.

DIGITAL HALFTONING

Images formed by the Digital Laser Platemaker will consist of a two-dimensional orthogonal array of fixed-size, binary dots. These dots are approximately 25 microns in diameter and are on 25 micron centers. This results in a raster matrix of over 1000 dots per inch and permits construction of textured patterns, or halftones, which can give the impression of gray (Roetling 1977).

If the available dots in the image plane are considered in groups, an average density for the group is available. For groups of one raster dot, the available densities are 0 and 1 representing the on/off binary nature of the dots. For groups of two, the available average densities for 0, 1, and 2 blackened (on) dots are respectively, 0, 1/2, and 1. Generally, for any group of binary dots the number of representable densities equals the number of dots plus one.

Example: A dot group composed of 4 binary modulated, fixed-size raster dots has 5 available average densities.



Average density for group

When raster dots are divided into groups in which none, some, or all of the dots turn black, intra-group patterns form. The group patterns found in digital halftone screens are dispersed, clustered, or some combination of both. Dispersed patterns have the dots as far apart as possible within the group blackened. Clustered dot patterns have blackened dots close together. The digital halftone function decides whether or not to turn a binary dot black. The choice is based on a repetitively or randomly determined matrix of clustered or dispersed thresholds. Values in the matrix correspond to positions in the binary dot group and screening is done by repeating the matrix across the input image (Jarvis 1976).

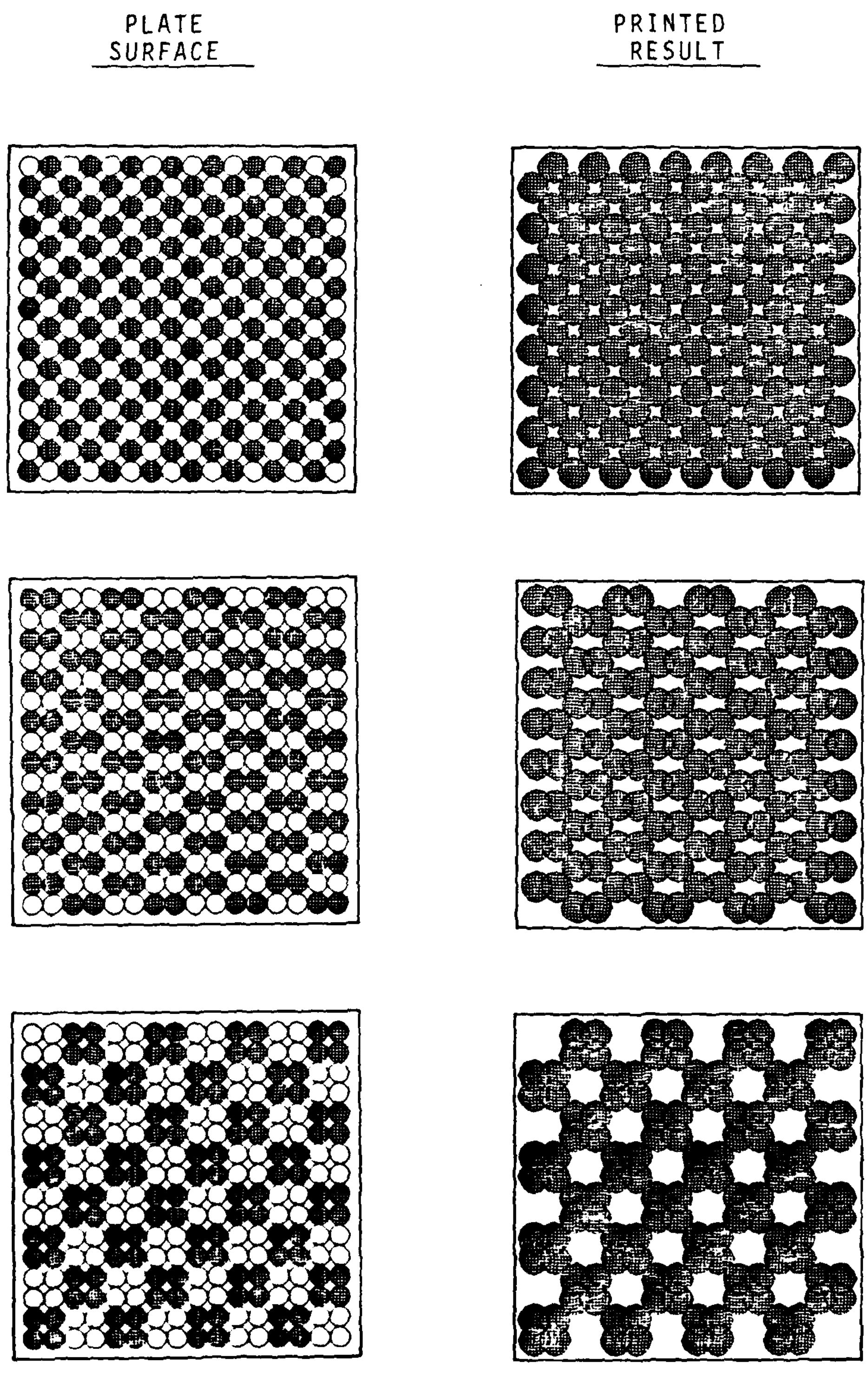
While several digital halftoning techniques are potentially useful for creating gray scale on the LPM printing plate, the special requirements imposed by ink on paper restrict the selection of a successful method.

A simple analysis demonstrates one aspect of the problem. Assume a 50 percent tint is desired in a given square inch on the final printed sheet. Turning on every other dot to form a black and white checkerboard pattern is an example of a dot pattern resulting from a dispersed threshold matrix. The LPM has 1016, 25 micron dots per linear inch with which to create the pattern. The resultant screen ruling is 508 lines per inch. At this screen frequency, the printing plate will most likely go 'blind' due to ink spread along edges. A digital screening technique using clustered dots avoids this problem by reducing the effective plotted screen ruling.

Figures 1 and 2 further illustrate the problem. Each of the circles in the 'windows' on the left side, represents one 25 micron, binary modulated, fixed-size raster dot. The windows show various attempts to create a 50 percent tint by burning one-half of the dots into the plate surface. The circles in the windows on the right side represent a printed dot. Diameter increase of the printed 25 micron dots is due to ink spread. Although each example has one-half of the dots printed in ink, the apparent gray scale varies.

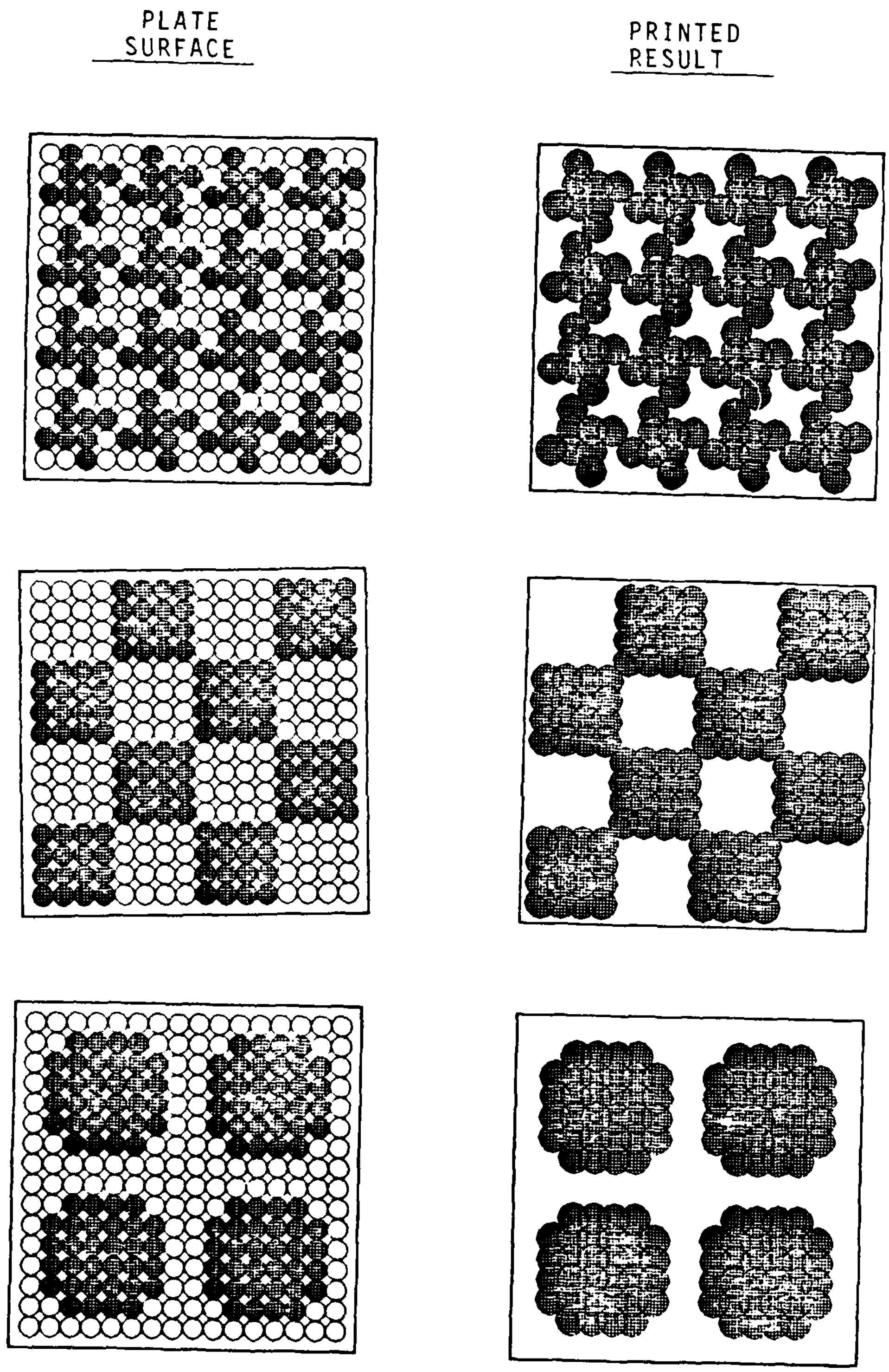
Further limitations are imposed by process color techniques. Moire in multiple screen printing results from the interaction of repetitive screen structures. Rotating photomechanical screens reduces the appearance of moire. In digital halftoning, specific screen rotation angles are limited by the nature of the orthogonal raster matrix. For example, rotating a raster dot from a position at X=0 and Y=10 by 30 degrees clockwise about the origin results in a calculated plot position of X=5 and Y=8.66. The closest plot position is at X=5 and Y=9. The resultant screen rotation angle at this point is 29.1 degrees. While algorithms for rotating digital screens exist (Holladay 1979) their effectiveness in multiple screen printing has yet to be determined.

Printed examples using the LPM will determine if angular errors due to the orthogonal raster matrix produce moire.



The dot groups down the page increase from dispersed to moderately clustered.

Figure 1.



The dot groups down the page increase from moderately clustered to clustered.

Figure 2.

Faithful gray-scale reproduction will also be examined. Production level software incorporating suitable digital halftoning techniques will be developed or procured based on test findings.

SUMMARY

The appeal of laser platemaking lies in its ability to create a printing plate directly from digital data. Intermediate photomechanical processing steps will be eliminated resulting in savings of time and materials. Incorporating known digital screening algorithms into raster processing software will achieve total automation of image formation. It is anticipated that the quality of maps produced on the Digital Laser Platemaker will equal or exceed that obtainable by conventional methods.

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